8053, 8054, 8055

Photomultiplier Tubes

2-INCH DIAMETER—8053
3-INCH DIAMETER—8054
5-INCH DIAMETER—8055

S-11 RESPONSE
10-STAGE, HEAD-ON TYPE

VENETIAN-BLIND
DYNODE STRUCTURE

For Use in Scintillation Counters for the Detection and Measurement of Nuclear Radiation

GENERAL

Spectral Response	S-11
Wavelength of Maximum Response	4400 ± 500 angstroms
Cathode, Semitransparent	Cesium-Antimony
Shape	Flat, Circular
Minimum area	
8053	2.20 sq. in
8054	5.27 sq. in
8055	15.0 sq. in
Minimum diameter	
8053	1.68 in
8054	2.59 in
8055	4.38 in
Window	Lime glass, Corning[a] No.0080, or equivalent
Shape	Plano-Plano
Index of refraction at 4360 angstroms	1.523
Dynodes	
Substrate	Copper-Beryllium
Secondary-Emitting Surface	Beryllium-Oxide
Structure	Venetian-Blind
Direct Interelectrode Capacitances (Approx.)	
Anode to dynode No.10	7 pF
Anode to all other electrodes	8.5 pF
Maximum Overall Length	
8053	5.81 in
8054	6.31 in
8055	7.69 in
Seated Length	
8053	4.87 ± 0.19 in
8054	5.38 ± 0.18 in
8055	6.75 ± 0.19 in
Maximum Diameter	
8053	2.31 in
8054	3.06 in
8055	5.31 in
Envelope	
8053	T16
8054	J24
8055	J42
Socket	Cinch[b] No.3M14, or equivalent

Magnetic Shield
- 8053 . . . . . .JAN[c] No.S-2004, or equivalent
- 8054 . . . . . .JAN[c] No.3MI4, or equivalent
- 8055 . . . . . .See *footnote* (d)

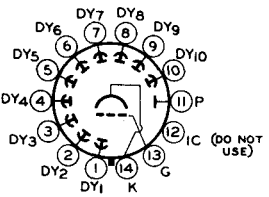
Operating Position . . . . . Any

Weight (Approx.)
- 8053 . . . . . 7 oz
- 8054 . . . . . 9 oz
- 8055 . . . . . 1 lb 7 oz

Base . . . . . Medium-Shell Diheptal 14-Pin (JEDEC Group 5, No.B14-38)

TERMINAL DIAGRAM (Bottom View)

Pin 1 – Dynode No.1
Pin 2 – Dynode No.2
Pin 3 – Dynode No.3
Pin 4 – Dynode No.4
Pin 5 – Dynode No.5
Pin 6 – Dynode No.6
Pin 7 – Dynode No.7
Pin 8 – Dynode No.8
Pin 9 – Dynode No.9
Pin 10 – Dynode No.10
Pin 11 – Anode
Pin 12 – Internal Connection—Do Not Use
Pin 13 – Focusing Electrode
Pin 14 – Photocathode



Unless indicated otherwise, the following ratings and characteristic range values apply to all types

ABSOLUTE-MAXIMUM RATINGS

DC Supply Voltage		
Between anode and cathode	2000	V
Between anode and dynode No.10	300	V
Between consecutive dynodes	250	V
Between dynode No.1 and cathode	600	V
Between focusing electrode and cathode	600	V
Average Anode Current[e]	2	mA
Ambient Temperature[f]	75	°C

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CHARACTERISTICS RANGE VALUES

Under conditions with dc supply voltage (E) across a voltage divider providing 1/6 of E between cathode and dynode No.1; 1/12 of E for each succeeding dynode stage; and 1/12 of E between anode and dynode No.10, except as noted. Focusing-electrode voltage is adjusted to that value between 50 and 100 per cent of dynode-No.1 potential (referred to cathode) which provides maximum anode current.

With E = 1500 volts except as noted

	Min	*Typ*	*Max*	
Sensitivity				
Radiant[g], at 4400 angstroms				
8053.	-	3.4×10^{4}	-	A/W
8054, 8055 . . .	-	3.5×10^{4}	-	A/W
Cathode Radiant[h] at 4400 angstroms				
8053.	-	0.056	-	A/W
8054.	-	0.064	-	A/W
8055.	-	0.088	-	A/W
Luminous:				
With tungsten light source[j]				
8053.	9	42	220	A/lm
8054.	9	43	220	A/lm
8055.	9	44	220	A/lm
With blue light source[k]				
8053.	9×10^{-6}	4.2×10^{-5}	2.2×10^{-4}	A
8054.	9×10^{-6}	4.3×10^{-5}	2.2×10^{-4}	A
8055.	9×10^{-6}	4.4×10^{-5}	2.2×10^{-4}	A
Cathode Luminous:				
With tungsten light source[m]				
8053.	-	7×10^{-5}	-	A/lm
8054.	-	8×10^{-5}	-	A/lm
8055.	-	1.1×10^{-4}	-	A/lm
With blue light source[n]				
8053.	6×10^{-8}	7×10^{-8}	-	A
8054.	6×10^{-8}	8×10^{-8}	-	A
8055.	6×10^{-8}	1.1×10^{-7}	-	A
Cathode Quantum Efficiency at 4400 angstroms:				
8053.	-	16	-	%
8054.	-	18	-	%
8055.	-	25	-	%
Current Amplification				
8053.	-	6×10^{5}	-	
8054.	-	5.4×10^{5}	-	
8055.	-	4×10^{5}	-	
Anode Dark Current[p] . .	-	4×10^{-9}	7×10^{-9}	A

	Min	Typ	Max	
Equivalent Anode-Dark Current Input	-	4.4×10^{-10} [q]	7.8×10^{-10} [q]	lm
	-	5.5×10^{-13} [r]	9.7×10^{-13} [r]	W
Equivalent Noise Input	-	3.4×10^{-12} [s]	1×10^{-11} [s]	lm
	-	4.2×10^{-15} [t]	1.3×10^{-14} [t]	W
Pulse-Height Resolution[u,v]	-	7.5	-	%
Mean Gain Deviation [u,w]				
With count rate change of 10,000 to 1,000 Hz[x]	-	1	-	%
For a period of 16 hours at a count rate of 10,000 Hz[y]	-	1	-	%
Anode-Pulse Rise Time[z]				
8053	-	1.2×10^{-8}	-	s
8054, 8055	-	1.4×10^{-8}	-	s
Electron Transit Time[aa]				
8053	-	5.9×10^{-8}	-	s
8054, 8055	-	6.5×10^{-8}	-	s

[a] Made by Corning Glass Works, Corning, New York. 14830

[b] Made by Cinch Manufacturing Company, 1026 South Homan Avenue, Chicago, Illinois. 60624

[c] Made by JAN Hardware Manufacturing Corp., 38-01, Queens Blvd., Long Island City 1, N. Y.

[d] Magnetic shielding material in the form of foil or tape as available from Magnetic Shield Division, Perfection Mica Company, 1322 N. Elston Ave., Chicago 22, Ill., 60622, or equivalent.

[e] Averaged over any interval of 30 seconds maximum.

[f] Tube operation at or below room temperature is recommended.

[g] This value is calculated from the typical luminous sensitivity rating using a conversion factor of 804 lumens per watt.

[h] This value is calculated from the typical cathode luminous sensitivity rating using a conversion factor of 804 lumens per watt.

[j] These values are calculated as shown below:

$$\text{Luminous Sensitivity (A/lm)} = \frac{\text{Anode Current (with blue light source) (A)}}{0.10 \times \text{Light Flux of } 1 \times 10^{-5} \text{ (lm)}}$$

The value of 0.10 is the average value of the ratio of the anode current measured under the conditions specified in footnote (k) to the anode current measured under the same conditions, but with the blue filter removed.

[k] Under the following conditions: Light incident on the cathode is transmitted through a blue filter (Corning C.S. No.5-58, polished to 1/2 stock thickness) from a tungsten-filament lamp having a lime-glass envelope. The lamp is operated at a color temperature of 2870° K. The value of light flux incident on the filter is 10 microlumens.

[m] This value is calculated as shown below:

$$\text{Cathode Luminous Sensitivity (A/lm)} = \frac{\text{Cathode Current (with blue light source) (A)}}{0.10 \times \text{Light Flux of } 0.01 \text{ (lm)}}$$

The value of 0.10 is the average value of the ratio of the cathode current measured under the conditions specified in footnote (n) to the cathode current measured under the same conditions but with the blue filter removed.

[n] Under the following conditions: Light incident on the cathode is transmitted through a blue filter (Corning C.S. No.5-58, polished to 1/2 stock thickness) from a tungsten-filament lamp having a lime-glass envelope. The lamp is operated at a color temperature of 2870° K. The value of light flux incident on the filter is 0.01 lumen and 200 volts are applied between cathode and all other electrodes connected as anode.

p At a tube temperature of 22° C. Light incident on the cathode is transmitted through a blue filter (Corning C.S. No.5-58, polished to 1/2 stock thickness) from a lime-glass envelope, tungsten-filament lamp operating at 2870° K. The light flux incident on the filter is 10 microlumens. The supply voltage E is adjusted to obtain an anode current of 9 microamperes. Sensitivity of these types under these conditions is approximately equivalent to 9 amperes per lumen. Dark current is measured with no light incident on the tube.

q With supply voltage E adjusted to give an equivalent luminous sensitivity of 9 amperes per lumen.

r At 4400 angstroms. This value is calculated from the EADCI value in lumens using a conversion factor of 804 lumens per watt.

s This value is calculated from the ENI value in watts using a conversion factor of 804 lumens per watt.

t At 4400 angstroms. Under the following conditions: Supply voltage (E) is as shown, 22° C tube temperature, external shield is connected to cathode, bandwidth 1 Hz, light source as shown under (k) interrupted at a low audio frequency to produce incident radiation pulses alternating between zero and the value stated. The "on" period of the pulse is equal to the "off" period. The output current is measured through a filter which passes only the fundamental frequency of the pulses.

u With the following voltage distribution: 3/13 of E between cathode and dynode No.1, 1/13 of E for each succeeding dynode stage, and 1/13 of E between dynode No.10 and anode. Focusing-electrode voltage is adjusted to that value between 50 and 100 per cent of dynode-No.1 potential (referred to cathode) which provides maximum anode current.

v Pulse height resolution is defined as the quotient of the full width of the photopeak at half height by the pulse height at maximum count rate under the following conditions: The 662 keV photon from an isotope of cesium having an atomic mass of 137 (Cs^{137}) and a cylindrical 3 inch x 3 inch thallium-activated sodium-iodide scintillator [NaI (Tl) - type 12D12] are used. This scintillator is manufactured by the Harshaw Chemical Corporation, 1945 East 97 Street, Cleveland 6, Ohio, and is rated by the manufacturer as having a resolution capability of 7.5%. The Cs^{137} source is in direct contact with the metal end of the scintillator. The faceplate end of the crystal is coupled to the types by a coupling fluid such as Dow Corning Corp., Type DC200 (viscosity of 60,000 centistokes) — manufactured by the Dow Corning Corp., Midland, Michigan, or equivalent.

w Mean Gain Deviation is defined as follows:

$$MGD = \frac{\sum_{i=1}^{i=n} \left| \bar{p} - p_i \right|}{n} \cdot \frac{100}{\bar{p}}$$

where $\bar{p}$ = mean pulse height
p_i = pulse height at the "ith" reading
n = total number of readings

x Under the following conditions: The scintillator and Cs^{137} radiation source of (v) are employed. The radiation source is initially centered on the major axis of the tube and the scintillator, at a point providing a pulse count rate of 10,000 Hz. The pulse height of the photopeak is measured under this condition. Next, the radiation source is moved rapidly, in approximately 30 seconds, to a new position that is equivalent to a count rate of 1,000 Hz. The new position is also centered in the major axis of the tube. The pulse height under this condition is measured. Mean gain deviation is defined as shown in (w).

y Under the same conditions as shown in (x) except the tube is operated for a period of 1/2 hour with the radiation source located at the point providing a pulse count rate of 10,000 Hz. Following this time interval, the pulse height is sampled at this count rate at 1-hour intervals for a period of 16 hours. Mean gain deviation is defined as shown in (w).

z Measured between 10 per cent and 90 per cent of maximum anode-pulse height. This anode-pulse rise time is primarily a function of transit time variation and is measured under conditions with the incident light fully illuminating the photocathode.

aa The electron transit time is the time interval between the arrival of a delta function light pulse at the entrance window of the tube and the time at which the output pulse at the anode terminal reaches peak amplitude. The transit time is measured under conditions with the incident light fully illuminating the photocathode.

OPERATING CONSIDERATIONS

The *base pins* of these types fit a diheptal 14-contact socket, such as Cinch No. 3M14, or equivalent. The socket should be made of high-grade, low-leakage material, and should be installed so that incident light falls on the face end of the tube.

The *operating stability* of these types are dependent on the magnitude of the anode current. The use of an average anode current well below the maximum rated value of 2 milliamperes is recommended when stability of operation is important. When stability is of prime importance, the use of an average anode current of 10 microamperes or less, commensurate with satisfactory output signal, is recommended.

Electrostatic and magnetic shielding of these types may be required in some applications. When a shield is used, it must be at cathode potential.

The *high voltages* at which these types are operated are very dangerous. Care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions should include the enclosure of high-potential terminals and the use of interlock switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required.

Accompanying Typical Voltage-Divider Arrangements are recommended for use with these types. Recommended resistance values for the voltage dividers range from 10,000 ohms per stage to 1,000,000 ohms per stage. The choice of resistance values for any voltage-divider network is usually a compromise. If low values of resistance per stage are utilized, the power drawn from the regulated power supply and the required power rating of the resistors increase. Phototube noise may also increase due to heating if the divider network is mounted near the photocathode. The use of resistance values near 1 megohm per stage may cause deviation from linearity if the voltage-divider current is not maintained at a value of at least 10 times that of the maximum value of anode current, and may limit anode-current response to pulsed light. The latter effect may be reduced by connecting capacitors between the tube socket terminals for dynodes No. 7 and No. 8, dynodes No. 8 and No. 9, dynodes No. 9 and No. 10, and between dynode No. 10 and anode return. In addition to nonlinearity and pulse-limiting effects, the use of resistance values exceeding 1 megohm per stage make these types more susceptible to leakage effects between terminals with possible resulting deviation in interstage voltage leading to a loss of current amplification.

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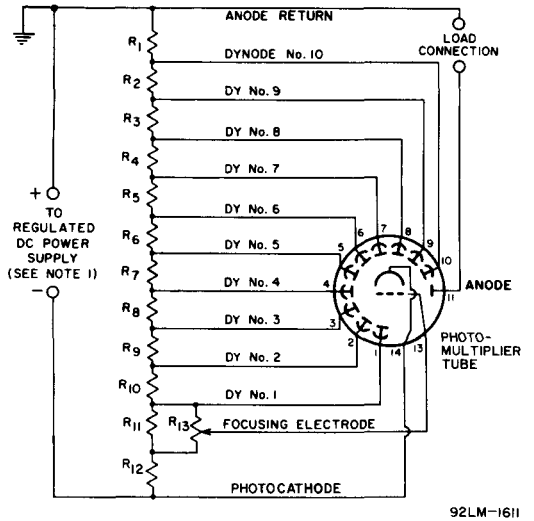
TYPICAL VOLTAGE-DIVIDER ARRANGEMENT FOR GENERAL PHOTOMETRIC APPLICATIONS

8053 8054 8055



R_1 through R_{12}: 470,000 ohms, 1/2 watt

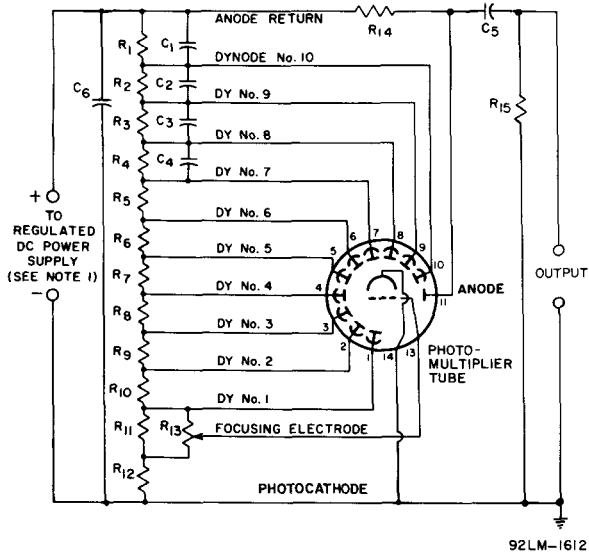
R_{13}: 5 megohms, 1/2 watt, adjustable

Note 1: Supply voltage should be adjustable between approximately 800 and 2000 volts dc.

Note 2: Component values are dependent upon nature of application and output signal desired.

TYPICAL VOLTAGE-DIVIDER ARRANGEMENT FOR SCINTILLATION-COUNTING APPLICATIONS

8053 8054 8055



C_1: 0.05 μF, 500 volts (dc working)
C_2: 0.02 μF, 500 volts (dc working)
C_3: 0.01 μF, 500 volts (dc working)
C_4: 0.005 μF, 500 volts (dc working)
C_5 and C_6: 0.005 μF, 3000 volts (dc working)
R_1 through R_{10}: 470,000 ohms, 1/2 watt
R_{11} and R_{12}: 750,000 ohms, 1/2 watt
R_{13}: 5 megohms, 1/2 watt, adjustable
R_{14}: 1 megohm, 1/2 watt
R_{15}: 100,000 ohms, 1/2 watt

Note 1: Supply voltage should be adjustable between approximately 800 and 2000 volts dc.

Note 2: Capacitors C_1 through C_5 should be connected at tube socket for optimum high-frequency performance.

Note 3: Component values are dependent upon nature of application and output signal desired.

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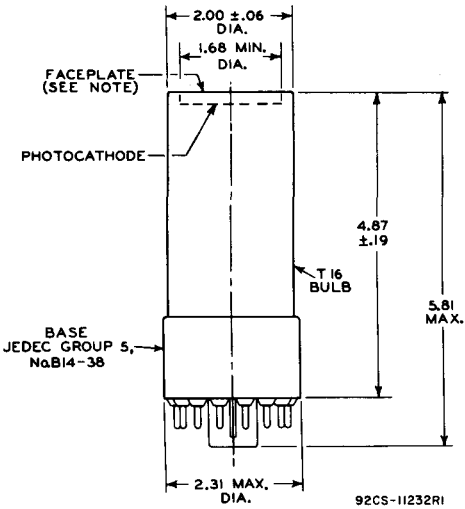
DIMENSIONAL OUTLINE

8053



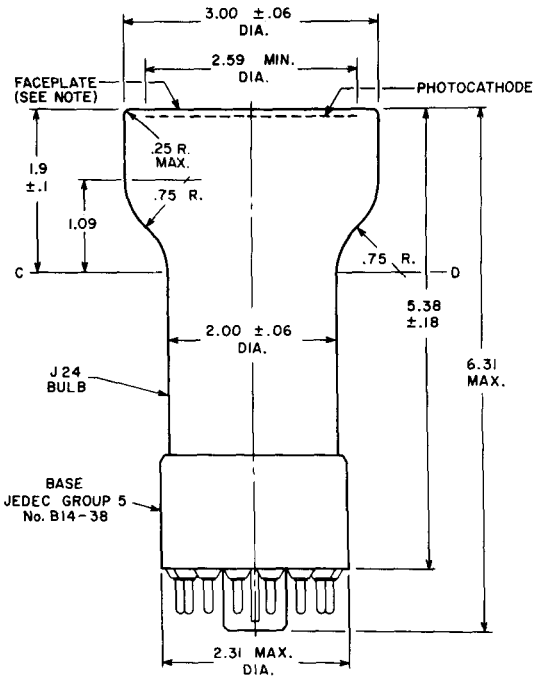
DIMENSIONS IN INCHES

Center line of bulb will not deviate more than 2^{o} in any direction from the perpendicular erected at the center of bottom of the base.

Note: Within 2.59-inch diameter, deviation from flatness of external surface of faceplate will not exceed 0.010-inch from peak to valley.

DIMENSIONAL OUTLINE

8054



92CM-11080R2

DIMENSIONS IN INCHES

Center line of bulb will not deviate more than 2° in any direction from the perpendicular erected at the center of bottom of the base.

Note: Within 2.59-inch diameter, deviation from flatness of external surface of faceplate will not exceed 0.010 inch from peak to valley.

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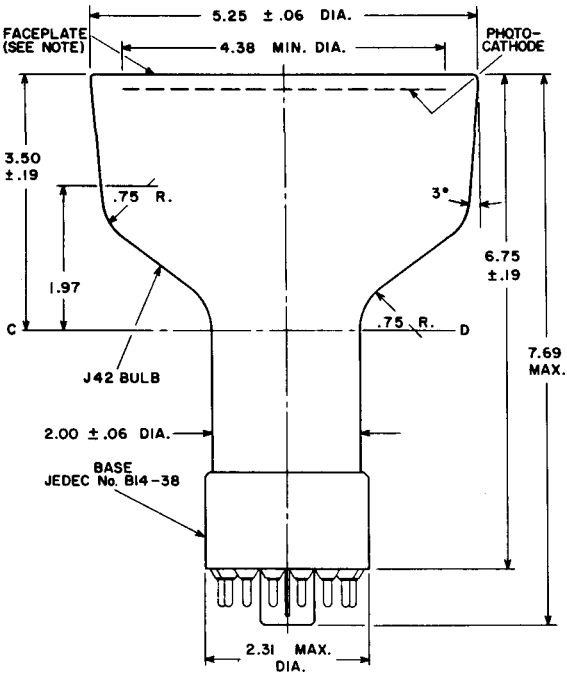
DIMENSIONAL OUTLINE

8055



92CM-11148R2

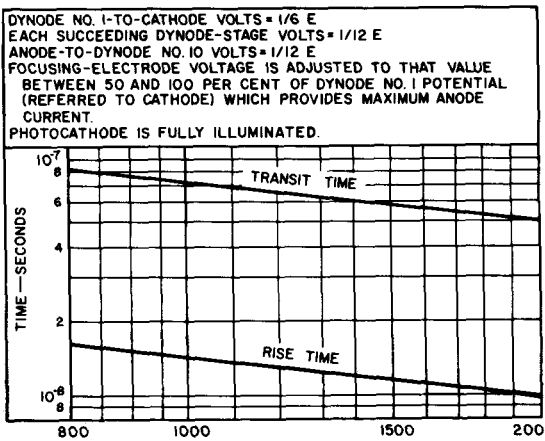
DIMENSIONS IN INCHES

Center line of bulb will not deviate more than 2° in any direction from the perpendicular erected at the center of bottom of the base.

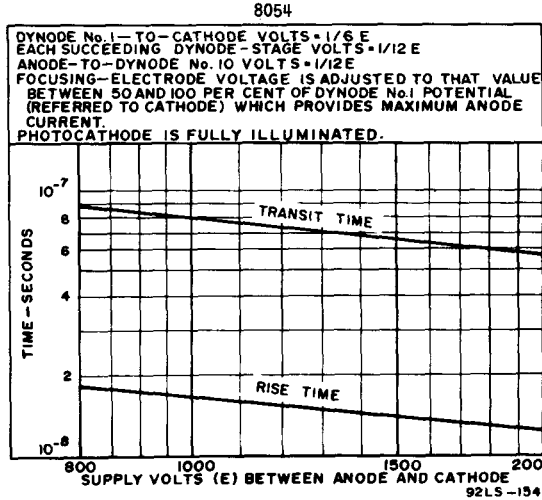
Note: Within 4.38-inch diameter, deviation from flatness of external surface of faceplate will not exceed 0.010 inch from peak to valley.

Typical Time Resolution Characteristics

8053



8054



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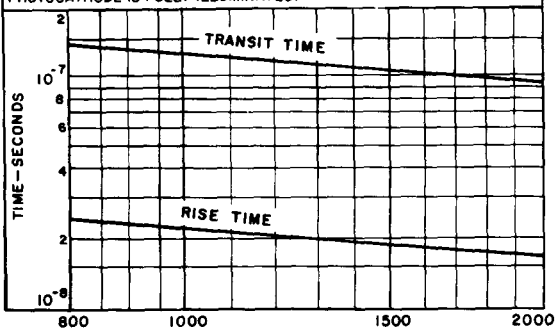
Typical Time Resolution Characteristics

8055

DYNODE NO.1-TO-CATHODE VOLTS = 1/6 E
EACH SUCCEEDING DYNODE-STAGE VOLTS = 1/12 E
ANODE-TO-DYNODE NO.10 VOLTS = 1/12 E
FOCUSING-ELECTRODE VOLTAGE IS ADJUSTED TO THAT VALUE BETWEEN 50 AND 100 PER CENT OF DYNODE-NO.1 POTENTIAL (REFERRED TO CATHODE) WHICH PROVIDES MAXIMUM ANODE CURRENT.
PHOTOCATHODE IS FULLY ILLUMINATED.



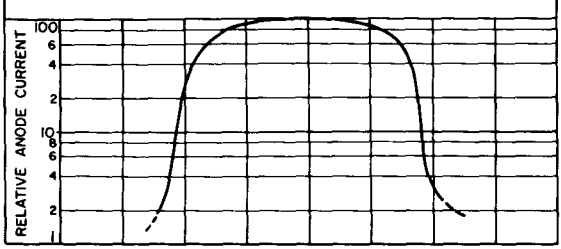
SUPPLY VOLTS (E) BETWEEN ANODE AND CATHODE

92LS-1546

Typical Characteristic of Output Current As a Function of Dynode-No.5 Volts

8053 8054 8055

DYNODE No.1-TO-CATHODE VOLTS = 200
VOLTS PER SUCCEEDING DYNODE STAGE EXCEPT FOR DYNODE-No.5 STAGE = 100
ANODE-TO-DYNODE No.10 VOLTS = 100
FOCUSING-ELECTRODE VOLTAGE IS ADJUSTED TO THAT VALUE BETWEEN 50 AND 100 PER CENT OF DYNODE-No.1 POTENTIAL (REFERRED TO CATHODE) WHICH PROVIDES MAXIMUM ANODE CURRENT.
ANODE IS AT GROUND POTENTIAL.



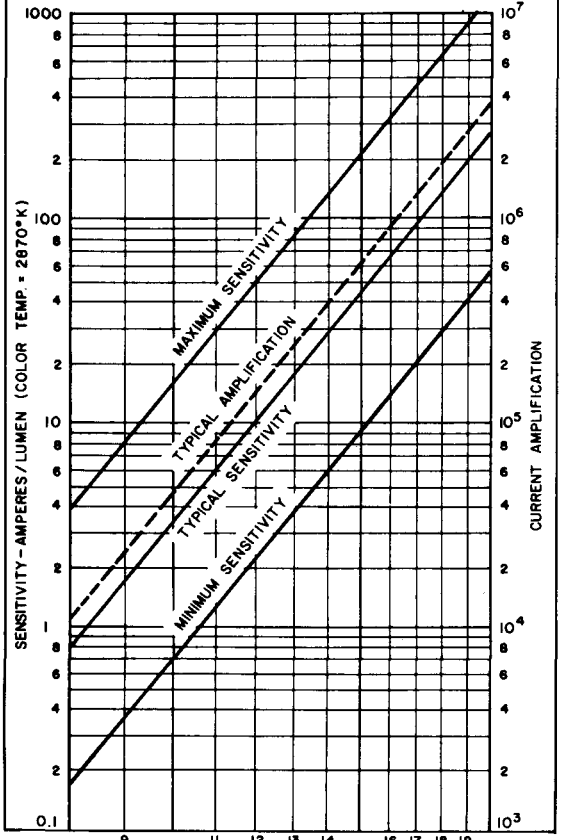
DYNODE No.5 VOLTS (REFERRED TO ANODE)

92CS-11078RI

Typical Sensitivity and Current Amplification Characteristics

8053

THE DC SUPPLY VOLTAGE (E) IS ACROSS A VOLTAGE DIVIDER PROVIDING 1/6 OF E BETWEEN CATHODE AND DYNODE NO.1; 1/12 OF E FOR EACH SUCCEEDING DYNODE STAGE; AND 1/12 OF E BETWEEN ANODE AND DYNODE NO.10. FOCUSING-ELECTRODE VOLTAGE IS ADJUSTED TO THAT VALUE BETWEEN 50 AND 100 PER CENT OF DYNODE-NO.1 POTENTIAL (REFERRED TO CATHODE) WHICH PROVIDES MAXIMUM ANODE CURRENT.



92LM-1545

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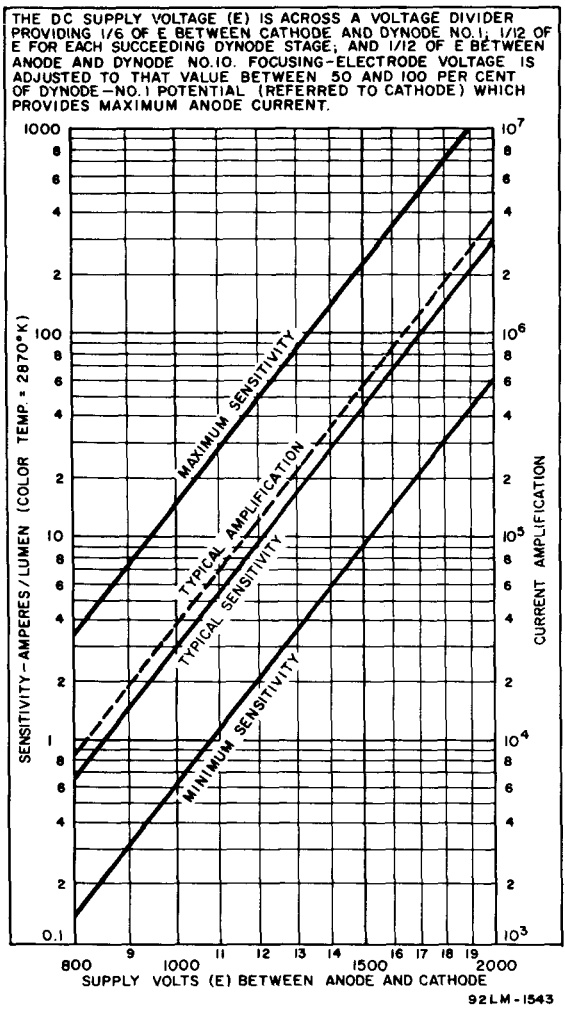
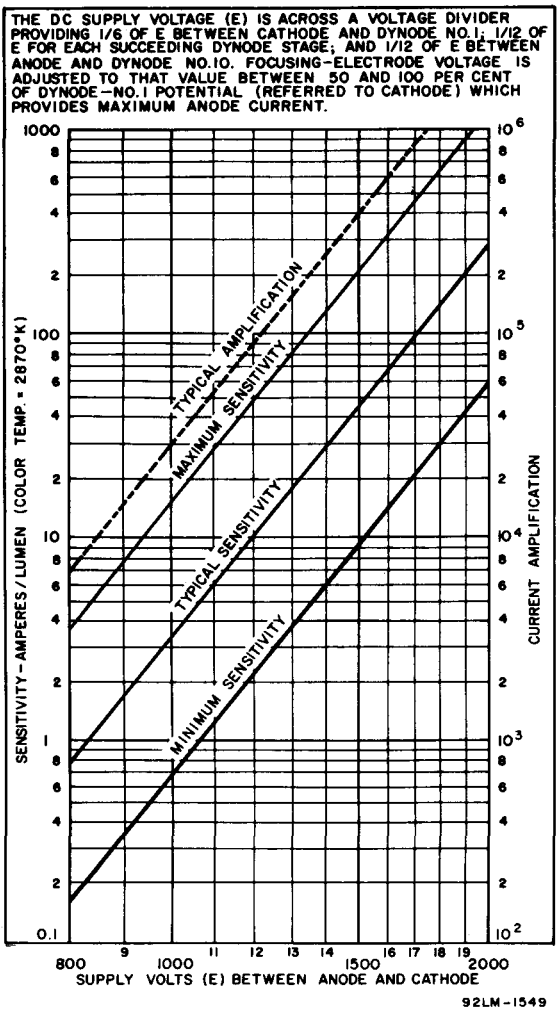
Typical Sensitivity and Current Amplification Characteristics

8054



Typical Sensitivity and Current Amplification Characteristics

8055



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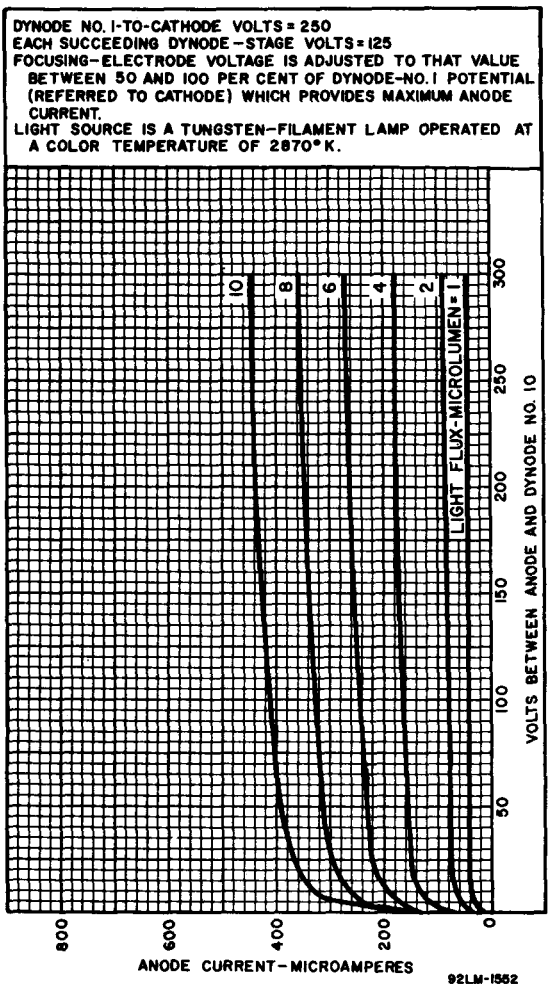
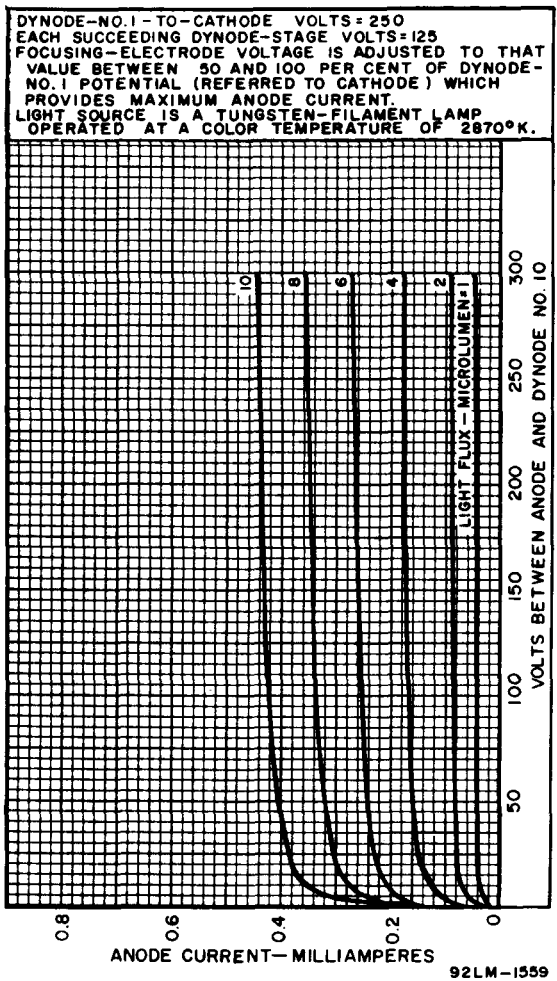
Typical Anode Characteristics

8053



Typical Anode Characteristics

8054



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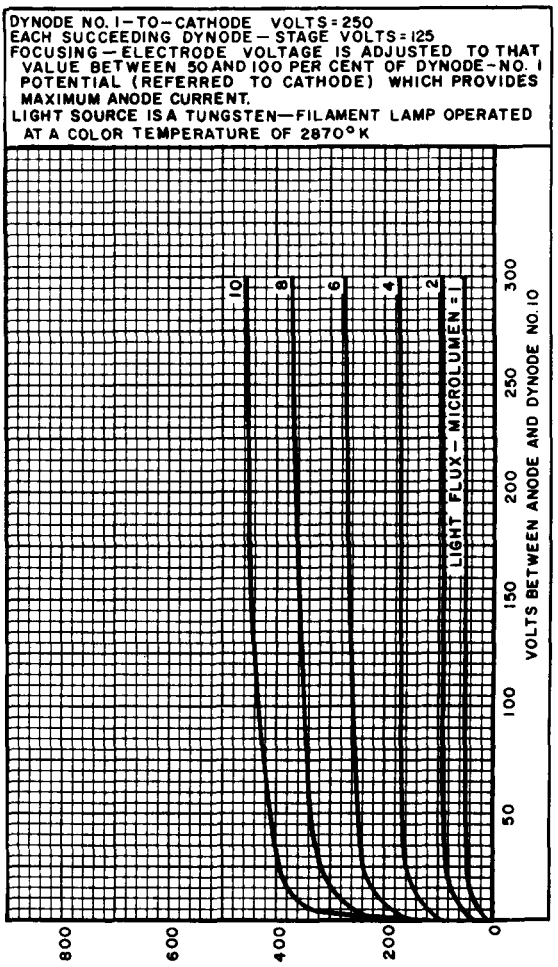
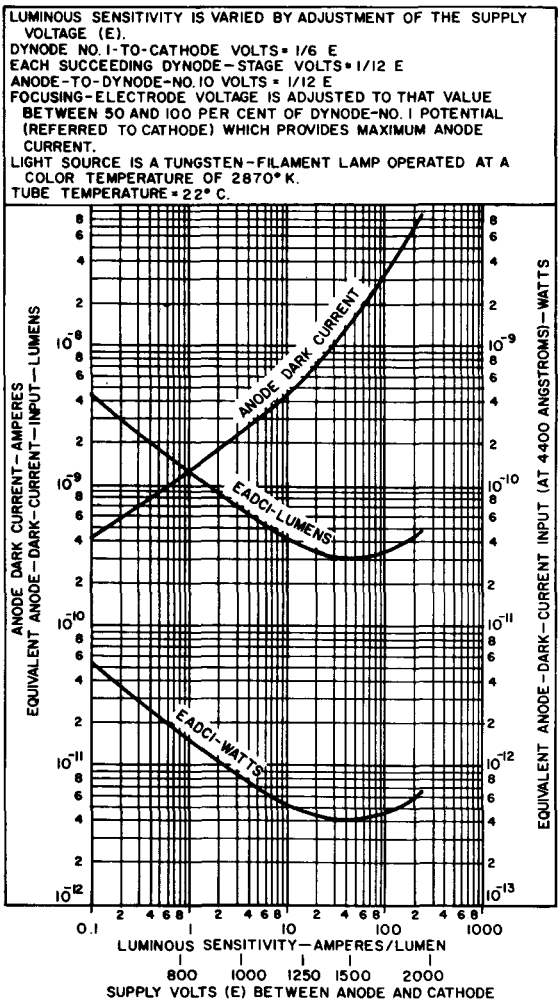
Typical Anode Characteristics

8055



Typical Dark Current and EADCI Characteristics

8053 8054 8055



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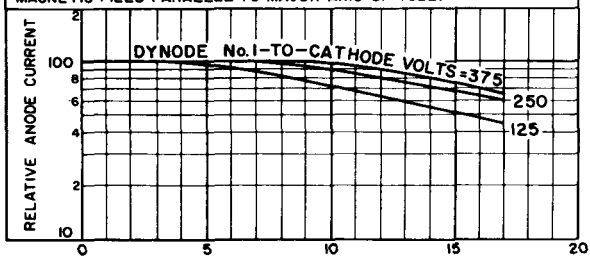
Typical Effect of Magnetic Field on Anode Current

8053

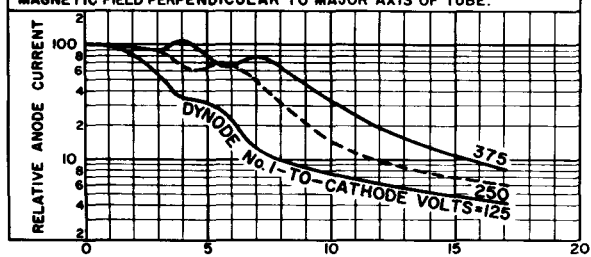
DYNODE No. 1-TO-CATHODE VOLTS = AS INDICATED
EACH SUCCEEDING DYNODE-STAGE VOLTS = 125
ANODE-TO-DYNODE No. 10 VOLTS = 125
FOCUSING-ELECTRODE VOLTAGE IS ADJUSTED TO THAT VALUE BETWEEN 50 AND 100 PER CENT OF DYNODE-No. 1 POTENTIAL (REFERRED TO CATHODE) WHICH PROVIDES MAXIMUM ANODE CURRENT.
PHOTOCATHODE FULLY ILLUMINATED BY A POINT LIGHT SOURCE POSITIONED APPROX. 1 FOOT FROM CENTER OF TUBE FACE.
MAGNETIC FIELD PARALLEL TO MAJOR AXIS OF TUBE.



92CS-11235R2

8053

DYNODE No. 1-TO-CATHODE VOLTS = AS INDICATED
EACH SUCCEEDING DYNODE-STAGE VOLTS = 125
ANODE-TO-DYNODE No. 10 VOLTS = 125
FOCUSING-ELECTRODE VOLTAGE IS ADJUSTED TO THAT VALUE BETWEEN 50 AND 100 PER CENT OF DYNODE-No. 1 POTENTIAL (REFERRED TO CATHODE) WHICH PROVIDES MAXIMUM ANODE CURRENT.
PHOTOCATHODE FULLY ILLUMINATED BY A POINT LIGHT SOURCE POSITIONED APPROX. 1 FOOT FROM CENTER OF TUBE FACE.
MAGNETIC FIELD PERPENDICULAR TO MAJOR AXIS OF TUBE.

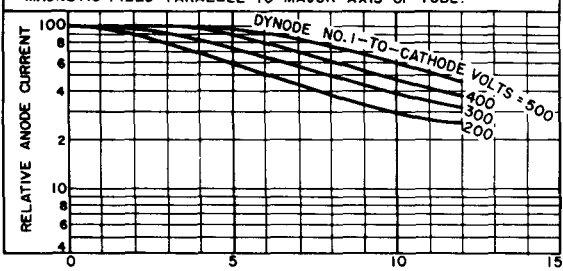


92CS-11236R2

Typical Effect of Magnetic Field on Anode Current

8054

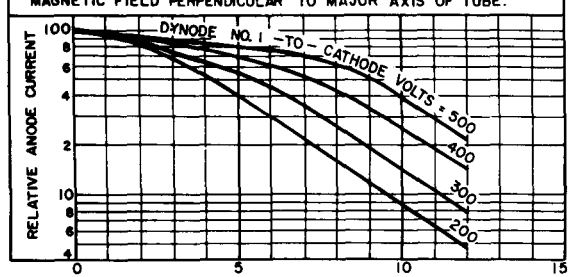
DYNODE No.1-TO-CATHODE VOLTS = AS INDICATED
EACH SUCCEEDING DYNODE-STAGE VOLTS = 125
ANODE-TO-DYNODE-No. 10 VOLTS = 125
FOCUSING-ELECTRODE VOLTAGE IS ADJUSTED TO THAT VALUE BETWEEN 50 AND 100 PER CENT OF DYNODE-No. 1 POTENTIAL (REFERRED TO CATHODE) WHICH PROVIDES MAXIMUM ANODE CURRENT.
PHOTOCATHODE FULLY ILLUMINATED BY A POINT LIGHT SOURCE POSITIONED APPROX. 1 FOOT FROM CENTER OF TUBE FACE.
MAGNETIC FIELD PARALLEL TO MAJOR AXIS OF TUBE.



92CM-11084R3

8054

DYNODE No.1-TO-CATHODE VOLTS = AS INDICATED
EACH SUCCEEDING DYNODE-STAGE VOLTS = 125
ANODE-TO-DYNODE No. 10 VOLTS = 125
FOCUSING-ELECTRODE VOLTAGE IS ADJUSTED TO THAT VALUE BETWEEN 50 AND 100 PER CENT OF DYNODE-No. 1 POTENTIAL (REFERRED TO CATHODE) WHICH PROVIDES MAXIMUM ANODE CURRENT.
PHOTOCATHODE FULLY ILLUMINATED BY A POINT LIGHT SOURCE POSITIONED APPROX. 1 FOOT FROM CENTER OF TUBE FACE.
MAGNETIC FIELD PERPENDICULAR TO MAJOR AXIS OF TUBE.



92CM-11085R3

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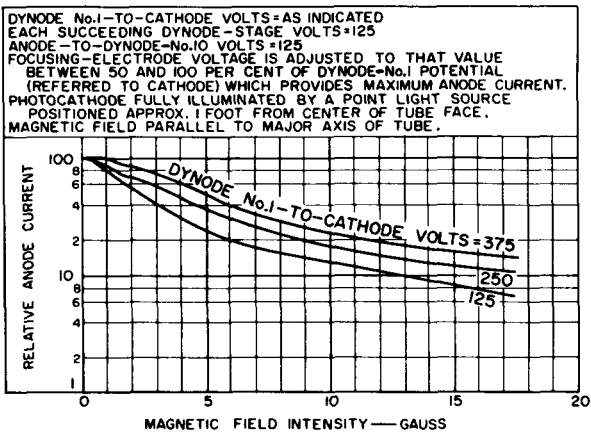
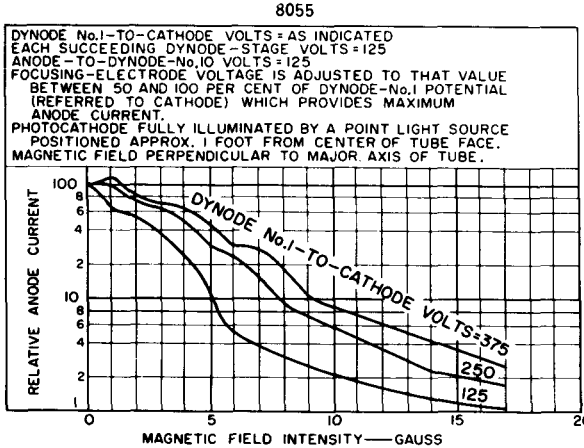
Typical Effect of Magnetic Field on Anode Current

8055



92CS-11187R2

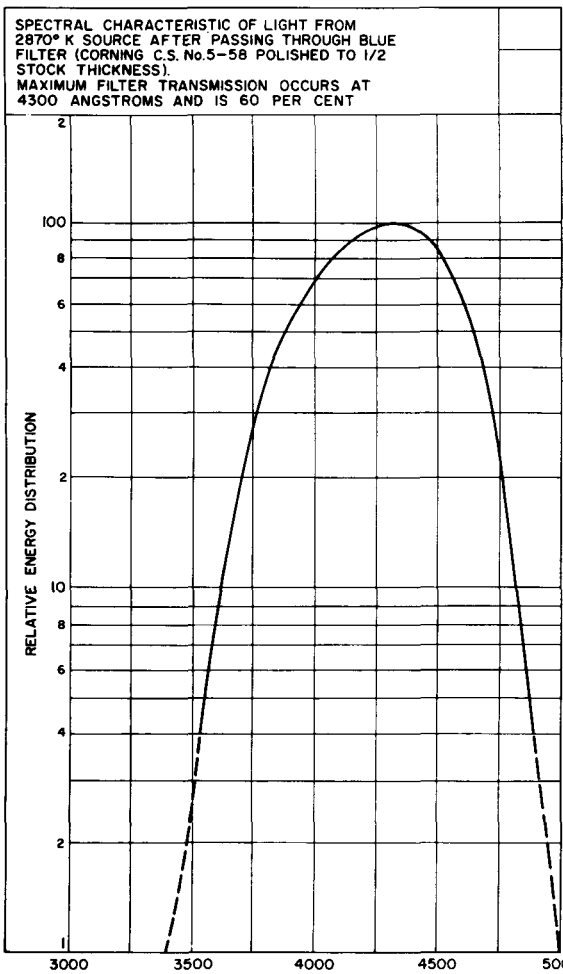
8055



92CS-11188R2

Spectral Energy Distribution of 2870°K Light Source After Passing Through Indicated Filter

8053 8054 8055



92CM-1108IRI

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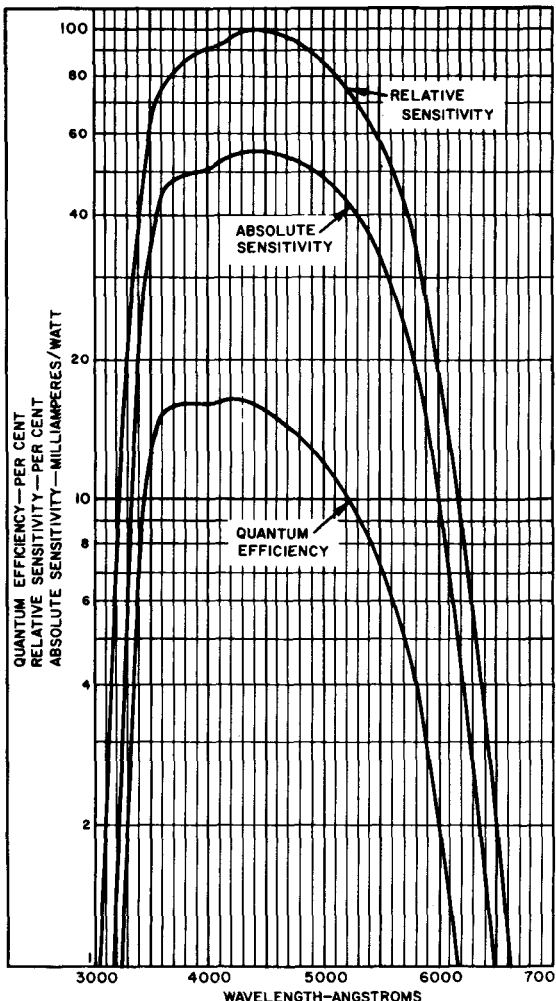
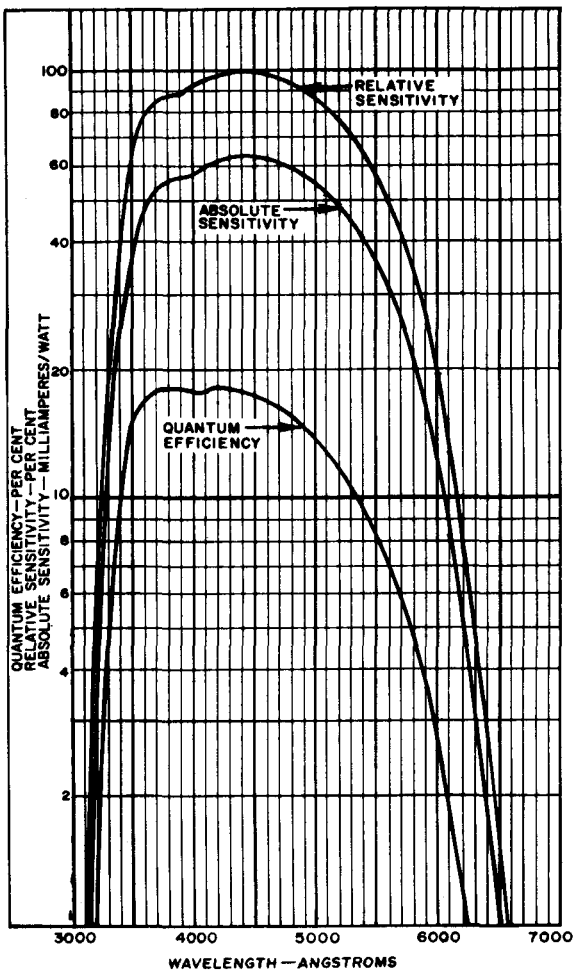
Typical Spectral Response Characteristics

8053



Typical Spectral Response Characteristics

8054



92LS-1842

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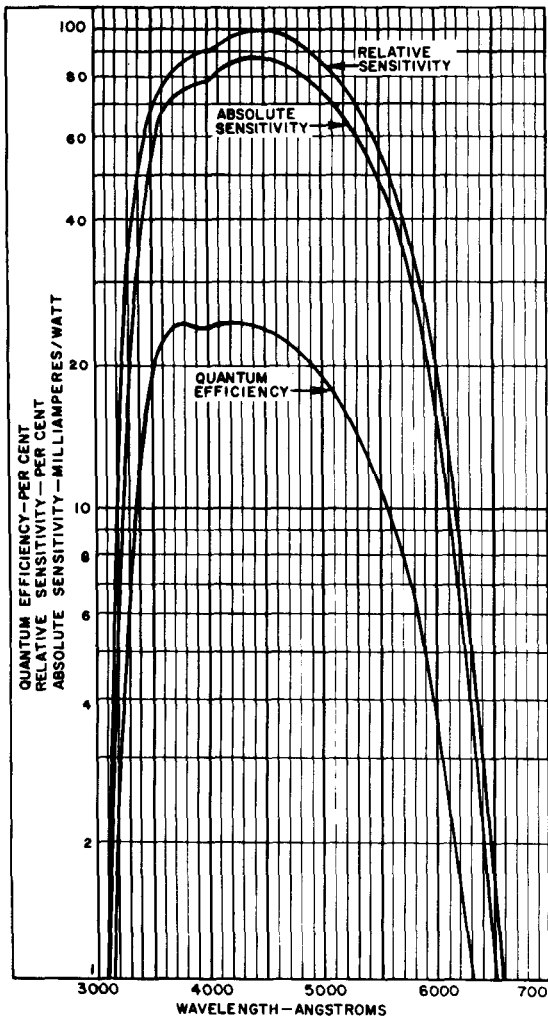
Typical Spectral Response Characteristics